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ABSTRACT

The document describes the use of weather maps and data in teaching introductory college courses in synoptic meteorology. Students examine weather changes at three-hour intervals from data obtained from the "Monthly Summary of Local Climatological Data." Weather variables in the local summary include sky cover, air temperature, dew point, relative humidity, wind direction, and wind speed. Atmospheric pressure data are obtained from "Surface Weather Observations" (National Weather Service). A specific study of the path of a cyclone indicates that the three, four, and six-hour interval studies offer accuracy in prediction whereas a two-hour interval study is not as accurate. Results also indicate that temperature is the most important variable for defining frontal boundaries. The author suggests using hourly pressure data as a supplement to the local summary. This combination should provide a sufficient data base for students to apply weather forecasting principles at shorter intervals of time. (KC)

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THE APPLICATION OF SYNOPTIC WEATHER FORECASTING RULES TO SELECTED WEATHER SITUATIONS IN THE UNITED STATES

Paper Presented at the

National Council for Geographic Education Meeting

in Mexico City

by

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Introduction

Introductory college courses in synoptic meteorology almost always utilize the easily acquired National Weather Service weekly series of daily weather maps, issued every 24 hours at 7 a.m. eastern standard time (E.S.T.). These daily surface maps provide students with weather data from hundreds of weather stations in the continental United States. Students can use each map to compare and contrast weather patterns affecting several different parts of the country. A sequence of these daily maps allows students to attempt general weather forecasting using well-known weather relationships associated with the model middle latitude cyclone. They can then evaluate their forecasts by referring to the next daily weather map. This trial and error process makes it possible for a student to become familiar with general synoptic weather patterns and principles as they apply in the middle latitudes of the northern hemisphere.

Unfortunately, during the 24 hour interval from one map to the next, weather changes occur which cannot be detected. A shorter interval of time would provide an additional dimension to synoptic weather forecasting by assisting students in observing more subtle changes in the weather. A three hour interval was chosen for this purpose because weather data at this interval is readily available from the Monthly Summary of Local Climatological Data. This data is also inexpensive, costing 25 cents a page. The weather variables obtained from the local summary included sky cover, air temperature, dew point, relative humidity, wind direction, and wind speed. An important weather variable missing from the local summary was atmospheric pressure adjusted to sea level. This information was obtained from Surface Weather Observations (form MF1-10A) issued by the National Weather Service.

The seven weather variables were plotted on separate maps at three hour intervals starting at 3 a.m. central standard time (C.S.T.) and ending at 9 p.m. C.S.T. for January 28, 1977. This date was chosen because it was associated with a well developed low pressure system that brought blizzard conditions to much of the eastern half of the United States. The weather contrasts on either side of the warm and cold fronts were considerable, thus making it easier to detect changes in the seven weather variables as the low moved eastward compared to a weaker developed cyclonic system. The number of first order weather stations used in the mapping varied from 53 to 77 depending on the variable (Map 1).

Problem

The main reason a three hour interval was chosen for a closer examination of the synoptic weather patterns on January 28, 1977 was convenience of acquisition and low cost. Concern developed as the three hour data was being evaluated about whether or not the correct interval had been chosen. Would the three hour interval reveal as much information as a two hour interval? Would a longer interval of four or six hours provide as much information at considerably less cost and effort?

It was decided to attempt an evaluation of the two, four, and six hour intervals, in addition, to the three hour interval. The source of information for these additional intervals was the Surface Weather Observations (form MF1-10A) mentioned earlier. This source was not used initially for the three hour interval because it was more costly and did not include hourly precipitation totals for the entire month that were included in the monthly local summary.

WEATHER

STATION

LOCATIONS

MAP 1

The criterion used to evaluate the four time intervals was how well each of the seven weather variables, when mapped, coincided with the actual path taken by the low pressure system on January 28, 1977. According to upper air patterns the system was moving in a general north-easterly direction (Map 1).

Each weather variable was evaluated first at the three hour interval. This preliminary investigation resulted in three of the seven variables being eliminated from further examination by the other three time intervals.

Results

Sky cover provided almost no correspondence with frontal position and the associated low. Relative humidity and wind speed revealed patterns which corresponded reasonably well with changes expected behind and in advance of the cold front, especially from 3 a.m. to noon. The position of the warm front, however, was difficult to draw with certainty on maps for these two variables. The fastest wind speed at each three hour interval was also plotted on a map in an attempt to try and locate the low pressure system. It was assumed that lowest atmospheric pressure would be closely associated with the greatest pressure gradient and associated high wind speeds. Unfortunately, there were several high wind speeds at each interval, several of them at considerable distances from one another.

The sudden shift in wind direction with the passage of a front was expected to be a better measure of the position of the low than the three previous weather variables. If the cold and warm fronts could be drawn on maps then their intersection should approximate the position of the center of the middle latitude cyclone. Shifts in wind direction were most pronounced

for the three hour interval along the cold front. Changes of 80 to 100 degrees from one time interval to the next, as the cold front passed, were not uncommon. Wind shifts along the warm front ranged from 30 to 70 degrees. It was possible to define the warm front only from 3 a.m. to 1 p.m. for the three hour interval. The partial success with wind direction at the three hour interval led to the evaluation of the two, four, and six hour intervals. The results for these additional intervals were very similar to the three hour interval. Again, wind direction was useful in defining both fronts, and the associated low, only before noon. The afternoon conditions did not permit the warm front to be drawn with any certainty.

Station pressure adjusted to sea level was expected to provide very good results, if not the best correspondence of any weather variable with the actual path of the low. Lowest pressure should be closely related to the center of the eastward moving cyclone. One approach involved plotting the migration of the lowest station pressure at each of the four different intervals on maps.

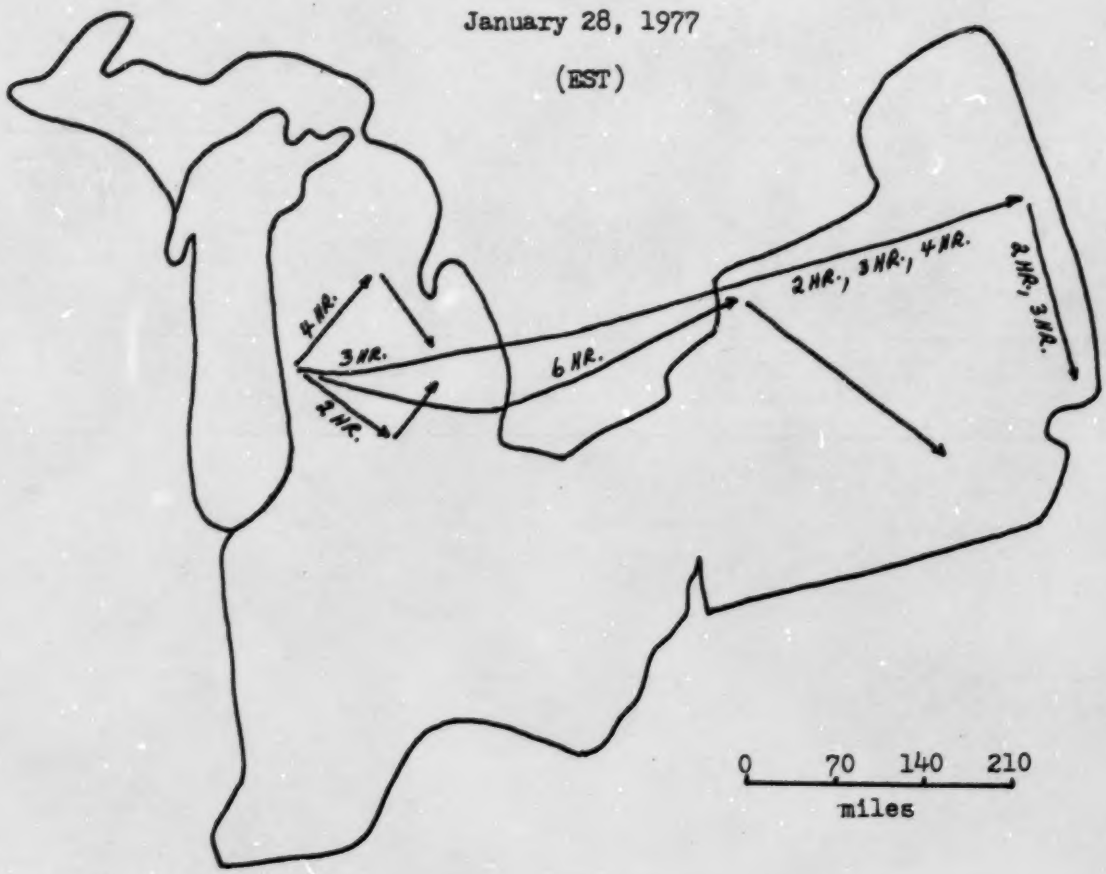
Each of the four time intervals was plotted at both C.S.T. and E.S.T. Each set of two, three, four, and six hour intervals was out of phase by one hour. The four hour interval for E.S.T. exhibited a slightly better correspondence with the actual path of the low than either the two or three hour intervals (Map 2). The six hour interval deviated the most and departed sooner from the path taken by the other intervals.

The four intervals recorded at C.S.T. exhibited much greater variation overall compared to the intervals recorded at E.S.T., especially after noon (Map 3). The best correspondence was the four hour interval, particularly until 5 p.m. The two hour interval was similar to the path followed by the

MIGRATION OF LOWEST PRESSURE(hourly intervals)

January 28, 1977

(EST)

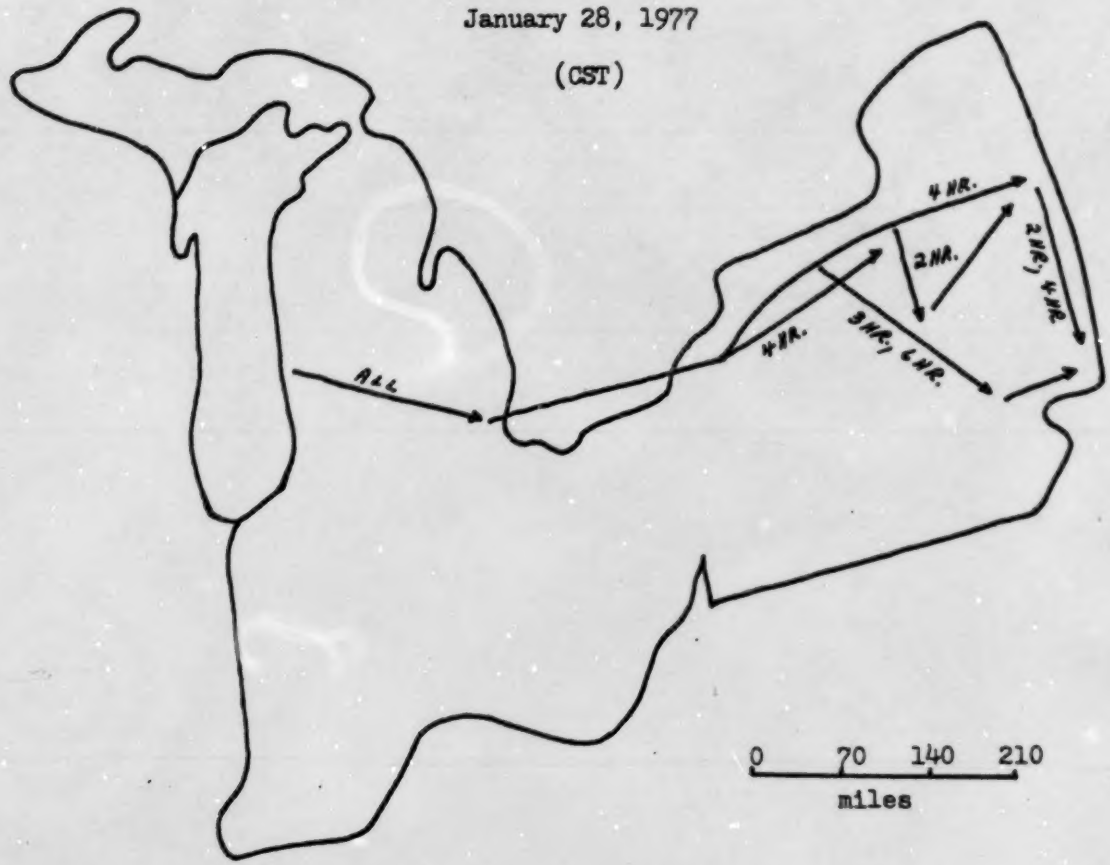


MAP 2

MIGRATION OF LOWEST PRESSURE(hourly intervals)

January 28, 1977

(CST)



MAP 3

four hour interval except that it had more north-south fluctuation. The three and six hour intervals revealed paths which departed sooner from the paths generated by the other two intervals.

The second approach used in evaluating pressure involved plotting the migration of maximum pressure decrease at each of the four different time intervals. Again, data was examined for both C.S.T. and E.S.T. The best match for the data recorded at E.S.T. was the four hour interval (Map 4). The two, three, and six hour intervals were about equal in their departures from the actual path of the low. The two hour interval might be considered a slightly better match than the three and six hour intervals because after its southward departure late in the day it moved in a northeasterly path similar to the actual low.

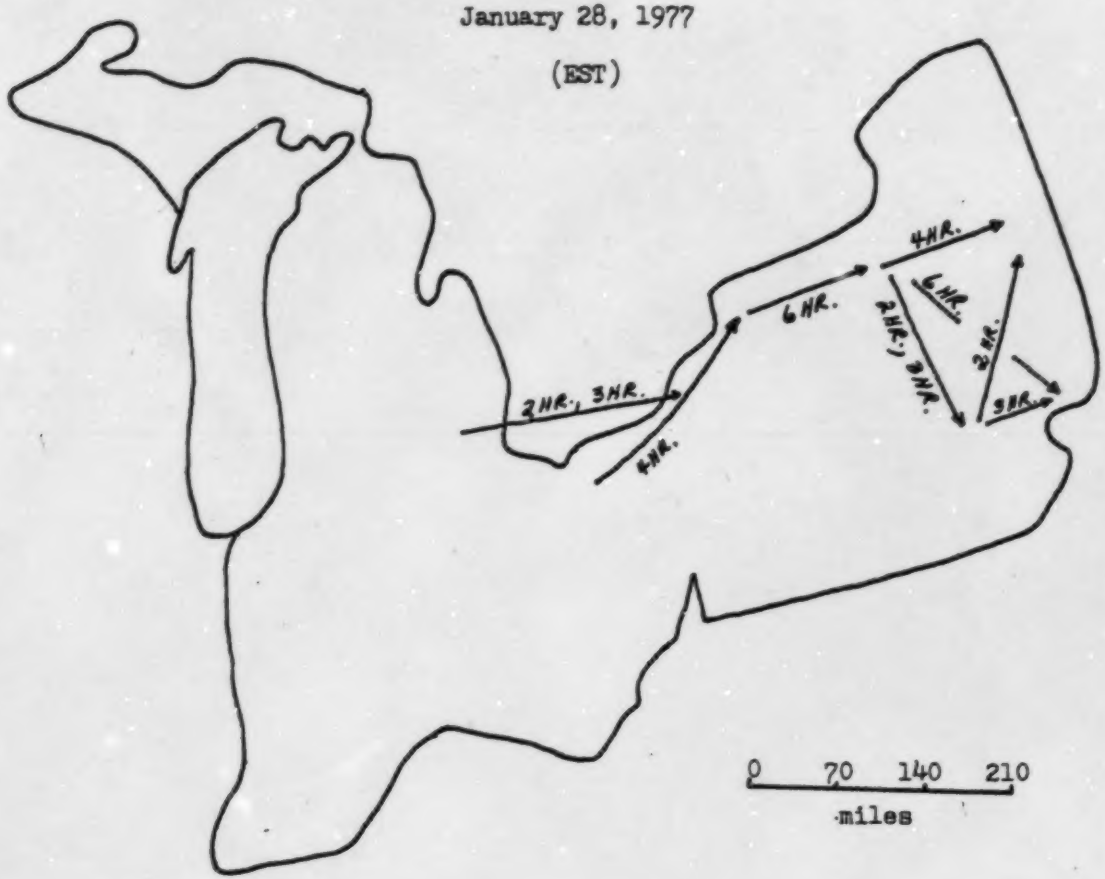
The maximum pressure change for the four different time intervals recorded at C.S.T. revealed that the six hour interval was the best match with the actual cyclone path (Map 5). The four hour interval was probably a slightly better match with the actual low than the two hour interval because it did not move southward after moving toward the northeast in the evening. The three hour interval departed the most compared to the other three time intervals. Overall, these four time intervals fluctuated much more in their paths than the four intervals recorded at E.S.T.

Temperature values for two, three, four, and six hour intervals were plotted for 67 stations on January 28, 1977. Temperature contrasts were pronounced enough to permit drawing the cold front, and especially the warm front. The intersection of the cold and warm fronts was plotted for each of the four intervals. The results were reasonably similar patterns of frontal migration for all four intervals (Map 6). The three and six hour intervals corresponded most closely to the actual path of the low toward the northeast. The four hour interval was just slightly less accurate than

MIGRATION OF MAXIMUM PRESSURE CHANGE(hourly intervals)

January 28, 1977

(EST)

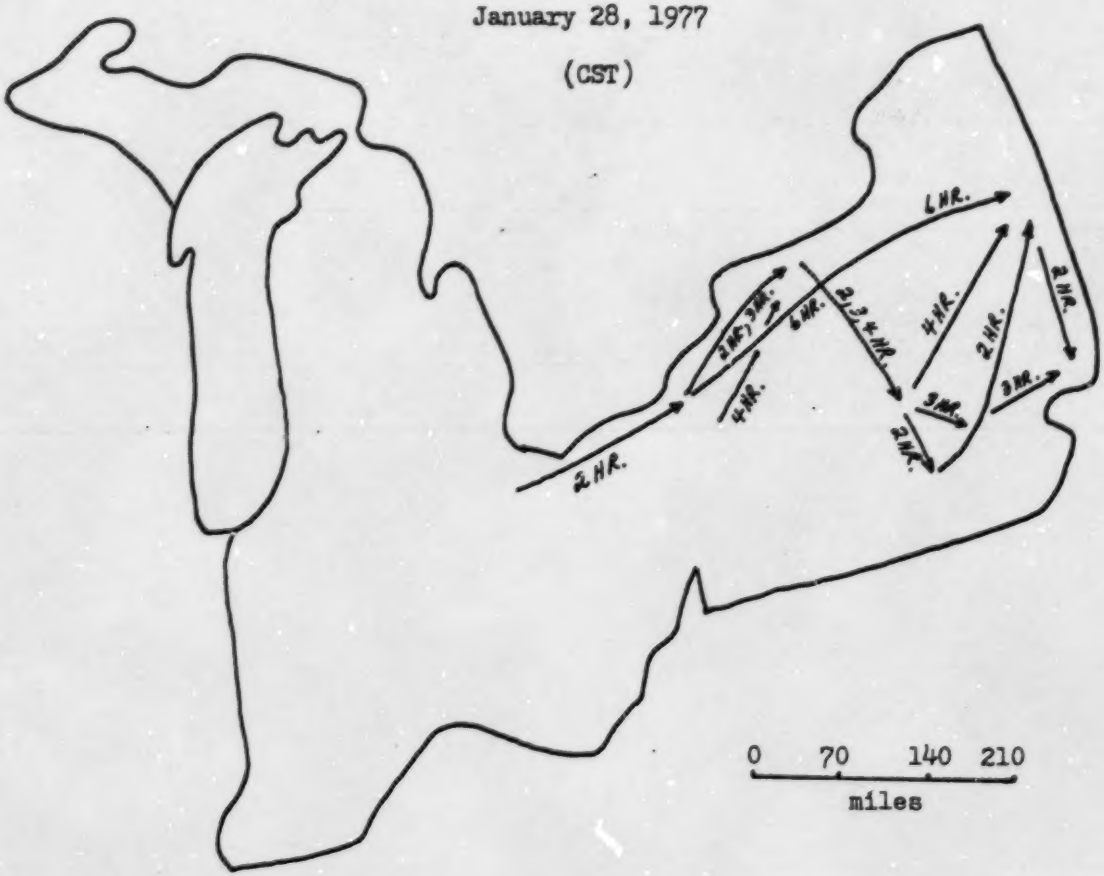


MAP 4

MIGRATION OF MAXIMUM PRESSURE CHANGE(hourly intervals)

January 28, 1977

(CST)

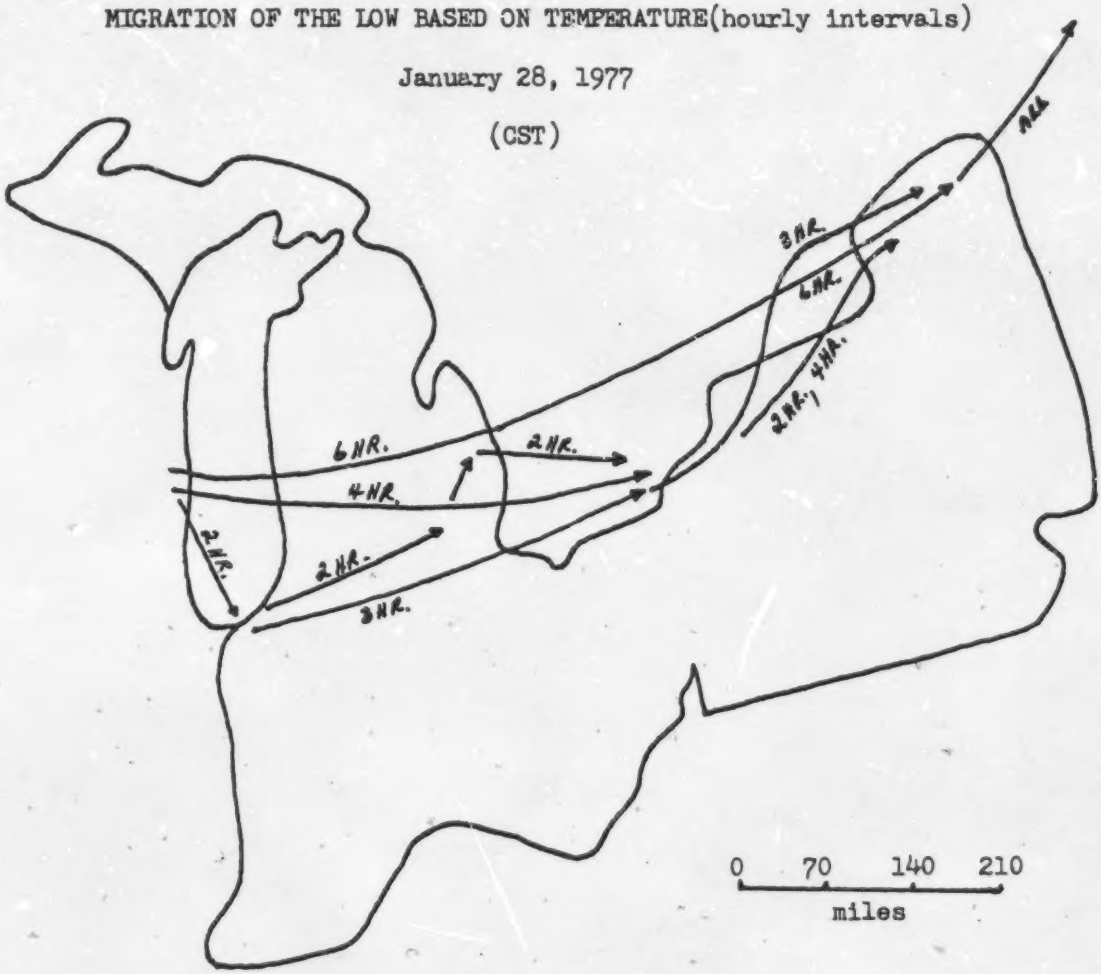


MAP 5

MIGRATION OF THE LOW BASED ON TEMPERATURE(hourly intervals)

January 28, 1977

(CST)



MAP 6

the three and six hour intervals. The two hour interval exhibited the most deviation from the actual path of the cyclone, especially in the early morning. The position of the low pressure system based on frontal intersection was, overall, a better estimate of the actual cyclone path than either type of pressure evaluation.

Finally, dew point temperatures were evaluated in the same manner as air temperatures. All four time intervals in this case displayed patterns very similar to those associated with frontal positions based on air temperatures (Map 6). The only minor difference was for the two hour interval for dew points which was a slightly better approximation of actual cyclone movement than the same interval for air temperature. This condition, however, did not prevail after 5 p.m. when air temperatures provided better contrasts for drawing fronts at both two and four hour intervals.

Summary

A major conclusion drawn from the results of this study is that the two hour interval did not offer as much accuracy in forecasting the path of the cyclone on January 28, 1977 as did the other three time intervals. In fact, the three, four, and six hour intervals were equally represented as best portraying the path of the middle latitude cyclone when pressure, temperature, and dew point were examined collectively. Individually, the four hour interval appeared to be the best one for interpreting the migration of lowest pressure and greatest change in pressure. These findings are somewhat tentative, however, because of the rather pronounced difference in results when pressure was analyzed at C.S.T. and E.S.T. The same interval provided considerable contrasts in results depending on when the

interval began. Part of this variation in the path of the cyclone could be related to the lack of pressure data in New England and Canada. If pressure data were available in these locations patterns might have conformed better. Also, local variations in topography in Pennsylvania and New York may have influenced sensitive pressure readings so that the unexpected variations occurred in this area. It remains for further investigation to determine how important such phase changes can be.

Another important finding is that both temperature, as well as, dew point permitted the plotting of the position of the low with greater accuracy than either the lowest pressure or greatest decrease in pressure. The three and six hour intervals were best in the case of these two types of temperature variables. This seems to confirm that temperature, even at intervals less than a day, is perhaps the single most important weather variable when it comes to defining frontal boundaries, and the position of the associated middle latitude cyclone.

It is recommended that since air temperature and dew point temperature provide patterns which have the strongest correspondence with the path of actual cyclone movement, that they be used as the basis for initiating the analysis of middle latitude low pressure systems if intervals shorter than 24 hours are desired. The three or six hour interval appears to offer good results and either could be chosen depending on time constraints. Local climatological data has the advantage that it is recorded at three hour intervals and is inexpensive to acquire. When using this source do not ignore the weather variables such as wind direction, wind speed, sky, and relative humidity. This data is also contained in the monthly summary and would be useful in providing a more complete interpretation of weather patterns.

If money is available hourly pressure data can be obtained to supplement the weather data contained in the local summary. A combination of both types of data should provide a sufficient data base to permit students to begin applying weather forecasting principles at shorter intervals of time. They can compare and contrast how well qualitative forecasting guidelines apply at shorter intervals. They may even attempt to develop new or modified forecasting principles based on results of using shorter time intervals.